Production and characterization of morphological and microstructural composite bulk or film for the study of interactions multiphysics

Production and morphological and microstructural characterization of composite bulk or film for the study of multiphysics interactions

Ph.D student: Pietro GALIZIA[1,2]

Supervisors: Prof. Giovanni MAIZZA[1]
Dr.ssa Carmen GALASSI[2]

[1]POLITECNICO DI TORINO
Corso Duca degli Abruzzi, 24, 10129 Torino (ITALY);

[2]CNR-ISTEC
Via Granarolo, 64, 48018 Faenza (ITALY)

Research activity

2012 November — Master Degree in **Materials Engineering** at the Politecnico di Torino

Thesis: Bi_2Te_3 / SiO_2 Thermoelectric nanocomposites: modelling and development

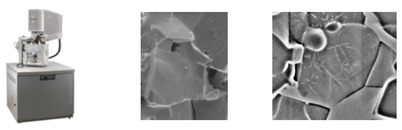
From 2013 May — **Fellow researcher** at the National Research Council of Italy, Institute of Science and Technology for Ceramics

Field: Materials and Ceramic Devices for Electromechanical Applications

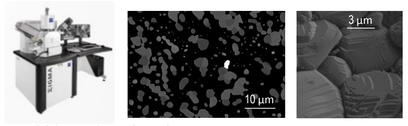
Supervisior: Dr.ssa Carmen Galassi

Activities:

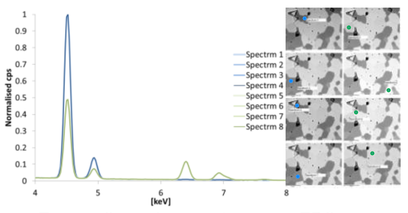
1. Microstructural Characterization



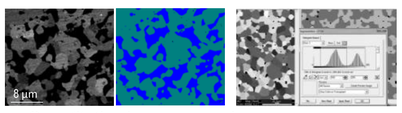
- FEI Quanta 200 ESEM™ scanning electron microscopy



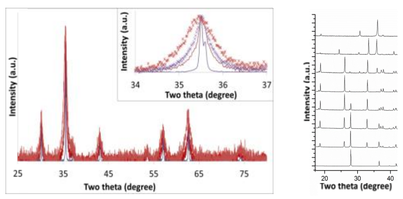
- SIGMA (FE-SEM) field emission scanning electron microscopy



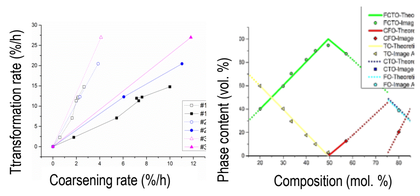
- Energy dispersive spectroscopy (EDS)



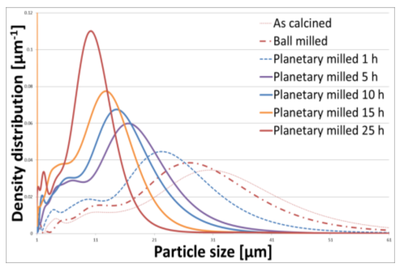
- Quantitative image analysis



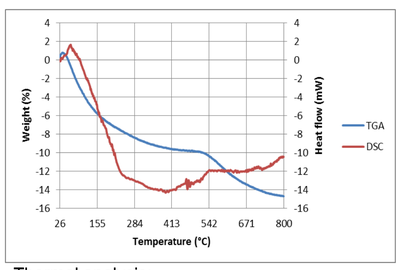
- Bruker D8 advace X-ray diffraction (XRD)
- Rigaku Geigerflex (XRPD)



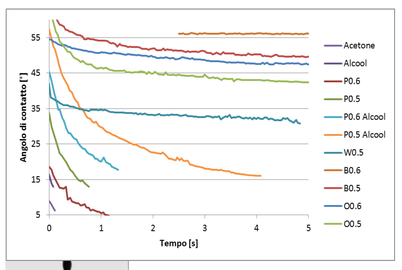
- Quantitative XRD analysis

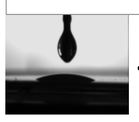


- Particle size distribution



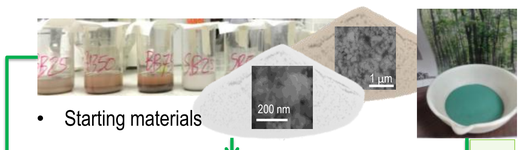
Thermal analysis:
- Thermogravimetric analysis (TGA)
- Differential scanning calorimetry (DSC)
- Simultaneous thermal analysis (STA)
- Thermo-dilatometric analysis (TDA)





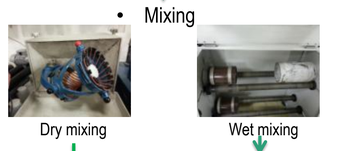
- Contact angle

2. Ceramic Processes



- Starting materials

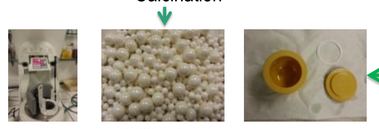
- Batching
- Mixing



Dry mixing — Wet mixing

- Drying

- Sieving
- Calcination



- Milling/mixing
- Drying

Oven — Rotary evaporator — Freeze-drying

- Sieving

POWDERS

- Shaping: Uniaxial pressing; Isostatic pressing
- Colloidal stabilization: Ball milling: -powder -solvent -binder -dispersant; Stirring; Stable suspension

- Electrophoretic deposition (**EPD**)

GREEN Bulks — GREEN Films

- Firing

SINTERED Samples

3. Scientific Training and Divulgation

- CCMX Advanced Course: "Powder Characterization and dispersion: from nanometers to millimeters and from theory to practice".
- Conference for Young Scientists in Ceramics. Oral presentation: "Thick dielectric films produced by electrophoretic deposition".
- Seminar: "Trattamenti superficiali e rivestimenti in una moto da competizione".
- 14th edition of ELECTROCERAMICS Conference. Oral presentation: "Structure analysis of cobalt ferrite/titania composite".
- Workshop SIMUFER MP0904. Poster presented: "Structure analysis of cobalt ferrite/titania-silica composite".
- Student contest presentation: 5th International Conference on Electrophoretic Deposition. Oral and poster presented: "Thick composite magneto-dielectric films produced by electrophoretic deposition".

Ph.D XXIX cycle

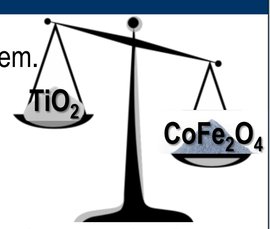
POLITECNICO DI TORINO — DISAT Department of Applied Science and Technology

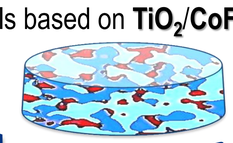
Ph.D. thesis title:
"*Production and characterization of morphological and microstructural composite bulk or film for the study of multiphysics interactions*"

Courses (A.Y. 2013-2014):
- X-ray diffraction by materials
- Metamaterials: electromagnetic theory and applications
- Competitive funds for research: from idea to written proposal

Materials and devices

✓ We studied *magneto-dielectric* composite materials based on TiO_2/$CoFe_2O_4$ system. These materials was used as substrate for **Miniaturized Microstrip Antennas**.

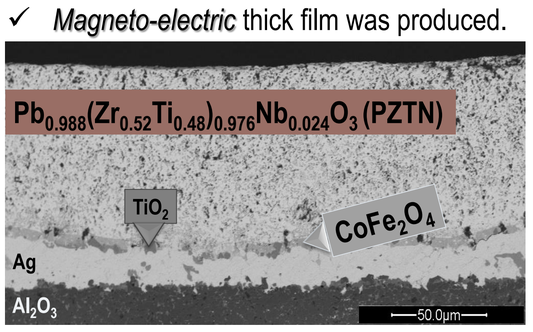


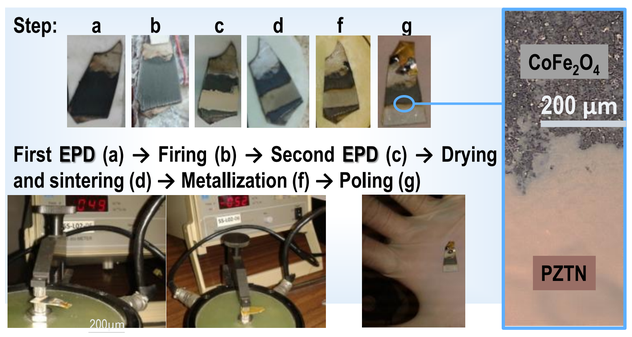


… The aim is to improve the magnetodielectric properties for wearable and wireless applications in the ultrahigh frequency; running activity: *core@shell* dielectric particles obtained by *electrocoagulation* or by microstructure control through the sintering process as *SPS* .

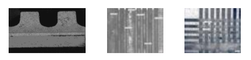
Others magnetic ceramics synthesized:
$BaFe_{12}O_{19}$; $SrFe_{12}O_{19}$; $Ba_{0.75}Sr_{0.25}Fe_{12}O_{19}$; $Ba_3Co_2Fe_{24}O_{41}$; $Sr_3Co_2Fe_{24}O_{41}$.

✓ *Magneto-electric* thick film was produced.

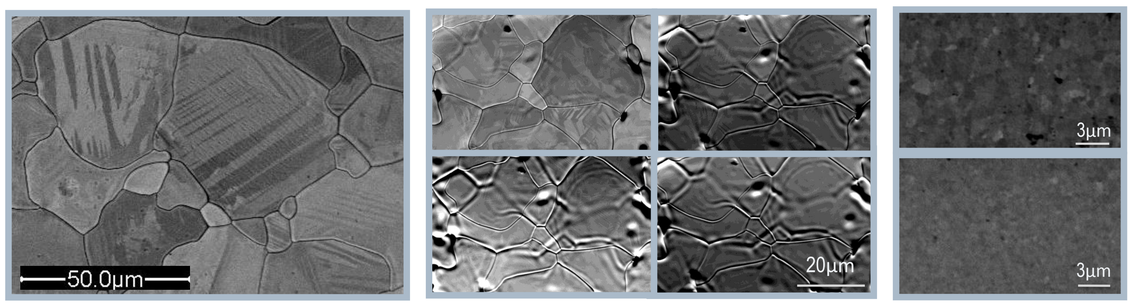




Others magneto-electric devices are incoming …



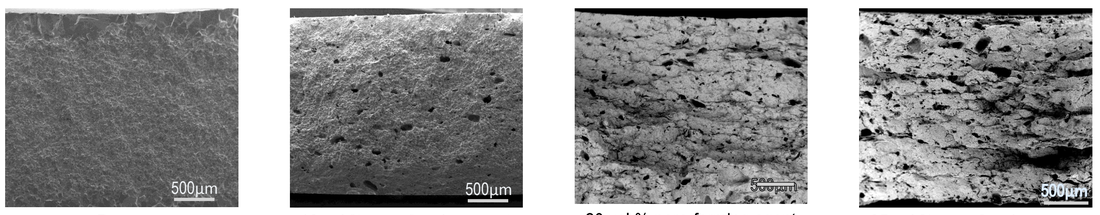
✓ We are investigating the extrinsic effect of grain size on the functional properties of $PbZr_{(1-x)}Ti_xO_3$, where x = 1, 0.98, 0.97, 0.96, 0.954, 0.95, 0.946, 0.938, 0.93, 0.925, 0.92, 0.88, 0.86 and 0.80.



This work is involving also on TiO_2 bulk ceramic materials.

Others studied *piezoelectric* materials are:
- lead titanate doped with iron, neodymium, manganese and samarium,
- $(BiNa)_{0.94}Ba_{0.06}TiO_3$
- barium strontium titanate.

✓ Porous BST ceramics with the nominal compositions $Ba_{(1-x)}Sr_xTiO_3$ samples were prepared by mixed-oxide method, where x = 0.6, 0.65, 0.7



Dense — 10 vol.% pore-forming agent — 20 vol.% pore-forming agent — 35 vol.% pore-forming agent

Work's outline

All the carried out work aims to the development of multifuctional ceramic composites with:

- **HIGH DENSITY**
- **MICROSTRUCTURAL HOMOGENEITY**
- **RELIABILITY**
- **COUPLED FUNCTIONAL PROPERTIES**

The goal is the application of these materials into commercial devices.
In order to achieve these objectives we are working on both single phases and mixtures while controlling and investigating processability and final functional properties of the materials.